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BY

S. H. KATZ

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INDUSTRIAL GAS MASKS ABROAD[1]

By S. H. Katz[2]

While working in England on a joint study conducted by the Safety in Mines Research Board of Great Britain and the United States Bureau of Mines, the writer had an opportunity to visit some of the plants manufacturing industrial gas masks and self-rescuers abroad, as well as some of the mine rescue stations where gas masks were tested for their proposed use in mines. This paper describes some of the industrial gas masks made abroad and the manufacturing plants, organizations, and laboratories dealing therewith, especially the carbon monoxide gas masks proposed for use in mines.

As the carbon monoxide gas mask was developed[3] in the United States and employed first in mines in this country designers in other countries are frequently referred here for guidance.

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1 - The Bureau of Mines will welcome reprinting of this article, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6206."

2 - Chemist formerly in charge of the gas-mask laboratory, Pittsburgh experiment station, U. S. Bureau of Mines; now with Chemical Warfare Service, Edgewood Arsenal, Maryland.

3 - (a) Frazer, J. C. W., and Scalione, C. C. Catalyst and Process for Making It: U. S. Patent 1345323, June 29, 1920.
Scanlione, C. C. and Frazer, J. C. W., Catalysts and Processes of Making Them: British Patent 166285, Jan. 7, 1920.
(b) Lamb, A. B., Bray, W. C., and Frazer, J. C. W., The Removal of Carbon Monoxide from Air: Ind. and Eng. Chem., vol. 12, 1920, pp. 213-221.
(c) Katz, S. H., Bloomfield, J. J., and Fieldner, A. C., The Universal and the Fireman's Gas Masks: Tech. Paper 300, Bureau of Mines 1923, 22 pp.
(d) Fieldner, A. C., Katz, S. H. Frevert, H. W., and Meiter, E. G., Gas Mask for Protection in Air Against All Gases, Vapors, and Smokes: Reports of Investigations Serial 2719, Bureau of Mines 1925, 11 pp.
(e) Katz, S. H., and McCaa, G. S., Use of a Type N Miner's Gas Mask: Miners' Circ. 32, Bureau of Mines 1928, 29 pp.

CONSTRUCTION OF GAS MASKS

It may be well to recall briefly the construction of the gas mask now used largely in rescue and recovery operations during fires or following explosions in American mines, especially as many of these masks have been sold abroad. Readers who know this mask may pass this description under the following heading.

American All-Service Gas Mask

The gas mask used in American mines is of the universal type[4] and is known as the All-Service. This mask has been tested and officially approved by the U. S. Bureau of Mines in accordance with its Schedule 14A.[5] It consists of four main parts: (1) The facepiece, (2) the timer, (3) the canister, and (4) the harness to support the canister on the wearer's chest.

The facepiece is of rubber covered with a stockinet fabric and forms a pocket over the face; this permits breathing through the nose, and the wearer may talk. Incoming air, dried during the purifying process, is discharged against the eyepieces inside to prevent fogging. Exhaled air passes downward and discharges through a non-return valve of rubber. Adjustable elastic headbands make this facepiece in one size adaptable to nearly all persons. The purified air is led to the facepiece through a corrugated, nonkinking rubber tube covered with stockinet. This tube joins the timer below.

The timer is a metal box that encloses a mechanism to move a luminous hand around a dial. One revolution is made in 2 hours of normal breathing, which is the approved period of the canister against carbon monoxide gas. Other gases may be noted by odor, taste, or irritating effects when they penetrate. Then the canister should be discarded in fresh air and a new one replaced, whether the 2-hour period has expired or not. The impulses of the breath move a disk on a lever that operates a ratchet. This moves a wheel with reducing gears operating the luminous hand. Although the timer is not very accurate it serves well enough for gas-mask purposes.

Beneath the timer, as the assembled mask is worn, is the canister containing the purifying chemicals to restrain poisonous gases. Figure 1 is a section of a canister with the timer above. Air enters the canister through a check valve at the bottom; a space permits access to all parts of the cross section; the air passes through the granular absorbents arranged in the order shown, which restrain all classes of poisonous gases thus:

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[4] - See footnote 3 c.

[5] - Bureau of Mines, Procedure for Establishing a List of Permissible Gas Masks: Fees, Character of Tests, and Conditions under Which Gas Masks will be Tested: Sched. 14A, Aug. 25, 1923, 15 pp.

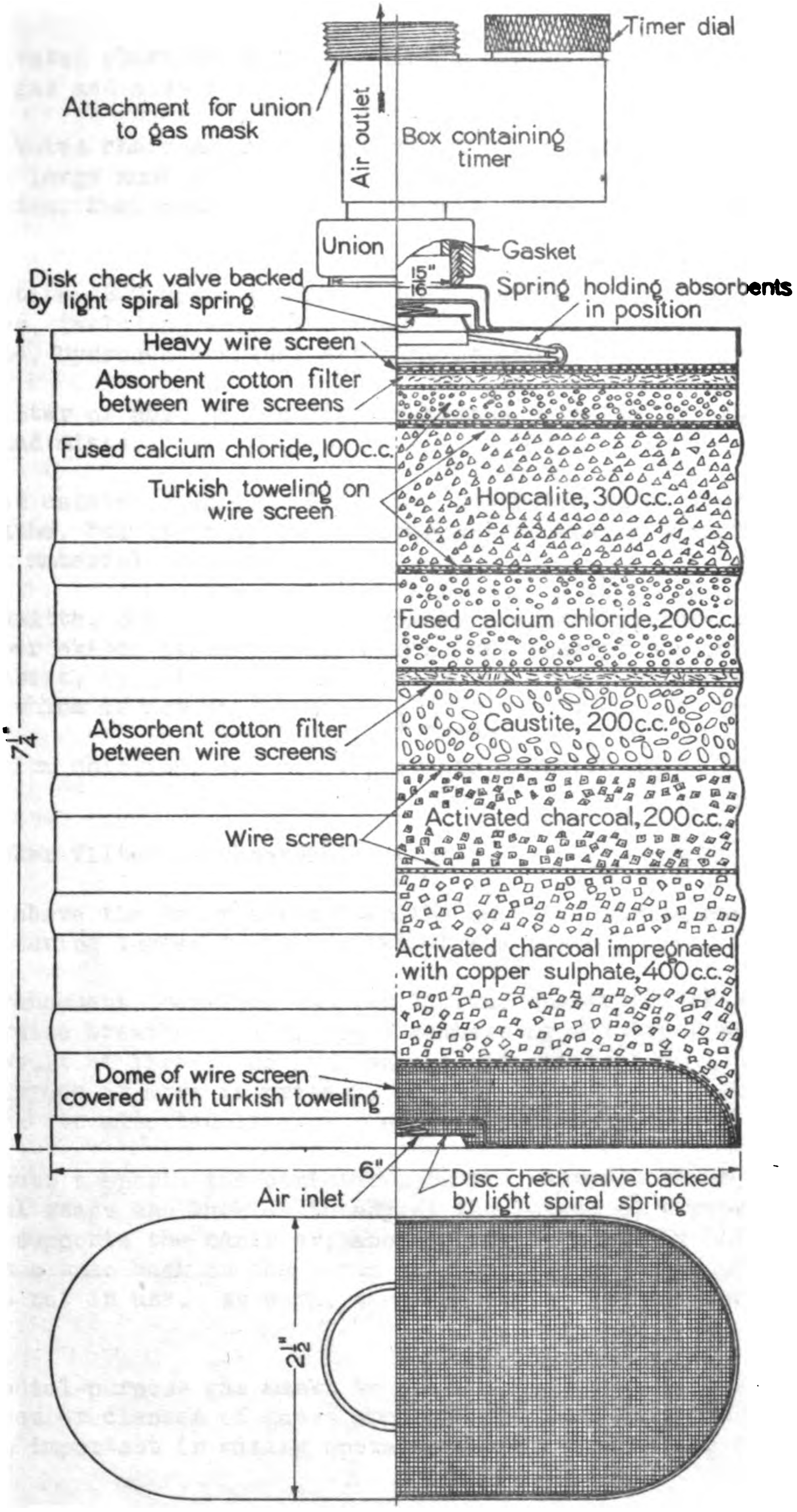
Timer dial
Attachment for union to gas mask
Air outlet
Box containing timer
Union
Gasket
15"
16
Disk check valve backed by light spiral spring
Spring holding absorbents in position
Heavy wire screen
Absorbent cotton filter between wire screens
Fused calcium chloride, 100 c.c.
Turkish toweling on wire screen
Hopcalite, 300 c.c.
Fused calcium chloride, 200 c.c.
Caustite, 200 c.c.
Absorbent cotton filter between wire screens
7¼"
Activated charcoal, 200 c.c.
Wire screen
Activated charcoal impregnated with copper sulphate, 400 c.c.
Dome of wire screen covered with turkish toweling
6"
Air inlet
Disc check valve backed by light spiral spring
2½"

Figure 1: Details of canister for All-Service gas mask

1. Activated charcoal impregnated with copper sulphate, 400 c.c., restrains ammonia gas and also some gases classed as organic vapors.

2. Activated charcoal unimpregnated, 200 c.c., restrains organic vapors. These comprise a large number of gases or vapors of organic chemicals, relatively neutral in reaction, including gasoline, benzene, alcohol, chloroform, and many more.

3. Caustite, 200 c.c., a caustic soda preparation, restrains a class called acid gases, including sulphur dioxide and hydrogen sulphide, formic acid, hydrogen chloride, hydrogen cyanide, and many others of similar nature.

4. A filter of absorbent cotton restrains suspensoids, including the smokes, dusts, and mists.

5. Fused calcium chloride, 200 c.c., restrains water vapor, which is harmless to breathe, but its removal is necessary because it inhibits the action of the next material, hopcalite.

6. Hopcalite, 300 c.c., is a specially prepared mixture of manganese dioxide and copper oxide; it serves as a catalyst, causing the poisonous carbon monoxide, if present, to unite chemically with the oxygen in the air to form carbon dioxide, which is not poisonous.

7. Calcium chloride, 100 c.c., prevents moisture above from approaching the hopcalite.

8. Another filter of absorbent cotton.

A space above the materials allows the purified air to pass from all parts of the filtering layers to the outlet at the center.

This arrangement therefore removes limited quantities of all poisonous gases from otherwise breathable air. Some members of all types of gas are found in mines as a result of fires. As long as a flame safety lamp indicates that 16 per cent of oxygen or more is present, the All-Service gas mask can protect the wearer during its allotted life of 2 hours.

The harness supports the canister upon the wearer's chest; it is made of fabric with metal snaps and buckles to adjust the length of straps. One strap around the neck supports the canister; another around the body holds it to the chest. There is a snap hook on the strap at the shoulder to support the facepiece when it is not in use. As worn, the All-Service gas mask weighs 5-1/2 pounds.

Many special-purpose gas masks to protect against a single gas or only two or three gases or classes of gases are made and used in the United States. As these are not important in mining operations they need not be considered here.

MINE ACCIDENTS AND SELF-RESCUERS

The self-rescuer is a small respirator made to hold in the mouth and with a noseclip adjoined for closing the nostrils. The wearer breathes through the self-rescuer which restrains carbon monoxide for at least one half-hour.[6] Self-rescuers have been used several years in mines of the United States, and one is now manufactured in Germany. The essential constituent in self-rescuers is hopcalite, together with a protecting layer of calcium chloride to restrain water vapor. Although self-rescuers have not come into use in mines abroad two accidents occurred last year which turned attention to their uses. One of the accidents was in France; the other was in England. Official reports of the former accident are not yet available, but a brief account of the latter in relation to the possible uses of self-rescuers may be given:

On the 18th of March, 1929, a fire[7] broke out in a mine near Birmingham, England. The morning shift was going to work. One group of 9 men nearing their working place in the mine passed a brattice at which nothing unusual was noticed. They had proceeded only a short distance when one of them looked back and saw the brattice afire. The men were trapped. One determined to chance an escape through the smoke and gas; he managed to crawl on his stomach under the gases to safety, although he was somewhat affected by the carbon monoxide. The others retreated from the fire as far as possible but when the rescue brigade reached them several hours later they were dead. Had self-rescuers been available it seems that all of these men might have escaped.

Both of the accidents mentioned drew considerable attention in the respective countries to the possible saving of lives had self-rescuers been available to the unfortunate miners.

GAS MASKS IN ENGLAND

Carbon Monoxide Gas Mask

Industrial gas masks are manufactured in England by Siebe, Gorman & Co. of London. This firm builds the well-known Fleuss-Davis Proto machine, an oxygen breathing apparatus employed by most mine rescue organizations in the British Isles and used in many other parts of the world. This firm also manufactures apparatus for deep-sea diving and appliances to supply aviators with oxygen at high altitudes, oxygen apparatus for reviving, gas masks, respirators, and other products. It has developed carbon monoxide gas masks[8] and also distributes the All-Service mask.

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[6] - Katz, S. H., and Forbes, J. J., Use of the Miner's Self-Rescuer: Miners' Circ. 30, Bureau of Mines 1928, 26 pp.

[7] - Wynne, F. H., Report on Causes and Circumstances Attending the Fire Which Occurred in the Workings of Coombs Wood Colliery on the 18th of March, 1929: Mines Department, Great Britain, 1929, 15 pp.

[8] - Levy, L. A., and Davis, R. H., Carbon Monoxide Respirator: British Patent 170404, July 20, 1920.
Levy, L. A., and West, D. W., Industrial Respirators: Chem. and Ind., vol. 40, 1921, pp. 234T-9T.

The carbon monoxide gas mask as developed in England has not been marketed to any considerable extent. The canister has, however, been partly described in the literature by Levy and West, already cited. It contains essentially five absorbent materials: (1) Calcium chloride to remove water vapor; (2) hopcalite to cause oxidation of the carbon monoxide, followed by another layer of calcium chloride; (3) a thin layer of iodine pentoxide and fuming sulphuric acid on pumice stone granules[9] for the purpose stated hereafter; (4) animal charcoal; and (5) filters of asbestos "lap" to restrain suspensoids as well as fumes of sulphur trioxide from the fuming sulphuric acid.

The iodine pentoxide and fuming sulphuric acid on the pumice granules is called "hoolamite" after the inventors. It oxidizes carbon monoxide at low temperatures with release of iodine. When the hopcalite in the canister after a period of usage begins to pass some carbon monoxide the hoolamite reacts with the carbon monoxide, iodine is freed, and some of the latter permeates the air being breathed. This iodine warns, by its mildly irritating effect on the nose and throat, of the escape of carbon monoxide. The thin layer of hoolamite is proportioned so that a warning is distinctly noticed when the carbon monoxide escaping the hopcalite is at 0.1 per cent concentration, but this concentration is reduced to an innocuous amount by the hoolamite. The thin layer of animal charcoal above the hoolamite is not highly active; it removes traces of iodine which may be liberated during the useful life of the canister, but permits some to pass when significant amounts arise due to the failure of the hopcalite.

Special Purpose Gas Masks

Many gas masks manufactured by Siebe, Gorman & Co. for gases other than carbon monoxide, as well as respirators for dusts, are used in British industry. In general construction and materials employed the canisters are very similar to those used in the United States, therefore no special description is warranted here. In fact, they are derived from the standard box respirator used by the British army during the World War, after which the American army gas masks were designed, and from the latter our own special purpose gas masks for industry are now patterned.

The facepieces of the British industrial masks are of the Tissot type, as are the American. The British facepiece is formed of a single piece of rubber by molding on forms; they are made with and also without fabric covering. Most other features are comparable with those of the American facepieces.

Two dust respirators manufactured by Siebe, Gorman & Co. are relatively high in filtering efficiencies and low in resistance to air flow, as indicated by tests in the gas masks and respirators laboratory of the Bureau of Mines at Pittsburgh;[10] these, called "pulvafilta" respirators, were developed by R. H.

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9 - Lamb, A. B., and Hoover, C. R., Absorbent: U. S. Patent 1321061, Nov. 4, 1919; Gas detector: U. S. Patent 1321062, Nov. 4, 1919.

10 - Katz, S. H., Smith, G. W., and Meiter, E. G., Dust Respirators; Their Construction and Filtering Efficiencies: Tech. Paper 394, Bureau of Mines 1926, 52 pp. (See figs. 6 and 7, pp. 13 and 14.)

Davis and C. G. Rosling in the company's laboratory. One is a half mask to cover only the nose and mouth; the other is a full mask with eyeglasses to cover the entire face. The entire outer surfaces of the masks are of woolen felt to make the filters; these are lined with rubberized fabric perforated by airways with valves. The valves permit only inhalation through the filters; exhaled air emerges through a nonreturn outlet. The full mask may be worn with comfort in cool situations, but it is not very comfortable where it is warm because of the heat retained on the face by the felt and rubber covering.

S.M.R.B. Gas-Mask Laboratory

The Safety in Mines Research Board installed a gas-mask laboratory in its new building in Sheffield in which to carry out research on the construction of carbon monoxide gas masks. The apparatus and equipment are the same in principle as employed by the Bureau of Mines at Pittsburgh. No gas chamber is available at Sheffield, but not far away at Doncaster one was placed at the disposal of the S.M.R.B. staff for testing gas masks by D. Macaskill, superintendent of the Doncaster and District Rescue Station. The gas chamber at Doncaster has a capacity of about 600 cubic feet.

S.M.R.B. Gas Mask

A device called the S.M.R.B. gas mask with a canister holding 1,500 c.c. of absorbents like those in the Universal gas mask[11] of the Bureau of Mines, was developed at the Sheffield laboratory. This mask has a low resistance to breathing obtained by modifying the canister to pass the gases through a broad cross-section instead of a narrow one as heretofore. The resistance of the canister alone is less than 1-1/2 inches of water when air flows at the uniform rate of 85 liters per minute; for the complete mask the resistance is about 2-1/2 inches. This compares with a maximum of 4 inches permitted in canisters and 5 inches for complete masks approved by the Bureau of Mines under its Schedule 14A. In other respects the S.M.R.B. gas mask meets the tests specified by the Bureau of Mines schedule. As the S.M.R.B. gas mask and the gas-mask laboratory at Sheffield are described fully in a paper[12] to be published by the Safety in Mines Research Board nothing more need be said here.

Regulations Concerning Respiratory Apparatus in British Mines

Respiratory apparatus are not permitted in British mines unless they have been tested and approved by the Board of Trade whose regulations[13] state -

> The breathing apparatus provided at a rescue station or mine in pursuance of the General Regulations of the 10th of July, 1913,

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11 - See footnote 3 c.

12 - Katz, S. H., and Grice, C. S. W., Mine Rescue Apparatus: The S. M. R. B. Gas Mask. Safety in Mines Research Board Paper. (In press.)

13 - Regulations and Orders Relating to Mines under the Coal Mines Act, 1911, Edition of 1926, including orders up to 31st January, 1927. Mines Department of Great Britain, 1927, 189 pp. p. 58.

> and 19th of May, 1914, with regard to rescue work shall be of a type for the time being approved by the Board of Trade, and no other breathing apparatus shall be used at any station or mine.***

The definition of "breathing apparatus" is given by the regulations thus:

> For the purpose of the foregoing regulation and of Part IV of the General Regulations above mentioned, breathing apparatus means an apparatus of such a character that the wearer carries with him all the means of respiration in an irrespirable atmosphere, and is not dependent for them, while in such an atmosphere, on any other person or persons.

At present this is construed to exclude gas masks from British mines, because the wearer of a gas mask does not carry with him "all the means for respiration"; that is, he does not carry the oxygen he requires, but obtains it from the air about him. The oxygen breathed is, of course, freed of any poisonous gases by the gas mask canister.

Furthermore, the regulations cited stipulate that a breathing apparatus under consideration for approval

> will not be regarded as satisfactory unless *** the highest resistance of the apparatus as a whole (measured immediately at the end of the 2-hour period) does not exceed 3 inches of water when the rate of flow is 85 liters per minute.

The 2-hour period referred to is an endurance test wherein

> the person wearing the complete apparatus will walk at a regular rate of 4 miles per hour on the level for a period of two hours, with rest intervals of not more than five minutes each at the expiration of 30, 60, 90 and 105 minutes.

The resistance of the existing All-Service gas masks now used in American mines may be as much as 5 inches of water when undergoing the tests for approval stipulated by Schedule 14A of the U. S. Bureau of Mines, and they do not meet the requirement of 3 inches stipulated above. Men who have worn the All-Service masks in England undergoing this test have complained that the resistance to breathing was excessive and so it was when 3 inches is considered a maximum. But it is believed that this new S.M.R.B. gas mask will overcome objections to gas masks as concerns the resistance. Then, should the regulations be modified to permit the use of gas masks where flame safety lamps burn, indicating 16 per cent or more of oxygen, it is believed that gas masks can fill a useful field in mine rescue, fire-fighting, and recovery operations in Great Britain.

GAS MASKS IN GERMANY

Gas masks are used widely in Germany by fire departments and the industries, but not yet in mines. The former especially are generally equipped, and nearly every fireman in Germany has a mask. The most popular mask is based on the German army mask used during the World War. It has a leather facepiece and a drum-shaped canister directly attached by a threaded male and female joint to allow changing the canisters. The headbands are of fabric with small spiral metal springs inclosed for elastics. Facepieces are also made of rubber and of rubberized fabric.

The mask forms a pocket over the wearer's face, and he breathes through his nose. There are no valves; both the inspired and expired air pass through the canister and filtering materials. Disks of gelatin to absorb moisture and prevent fogging are placed inside the eyepieces; these are changeable.

The drum canisters are made with absorbents in considerable variety for specific gases and classes of gases; moreover, a general purpose canister especially for fire departments restrains all classes of poisonous gases and smokes but carbon monoxide. The relatively small canister has a limited capacity and is intended for protection only where there is an abundance of fresh air to dilute greatly the gases from a fire or from any other source. The filter in this canister is effective only against relatively coarse suspensoids, as the canister is made with little resistance to breathing because the wearer must both inhale and exhale through it, which doubles the work imposed by the resistance in the canister. When greater filtering efficiency is needed for smokes or other suspensoids an additional filter disk of higher filtering efficacy may be clamped over the outer end of the canister by means of a special fitting of perforated metal.

Canisters of larger size and capacity are also made. They are supported by a harness on the wearer's body, usually on the left side or back, and a corrugated rubber tube leads from the canister to the facepiece. The facepieces are the same or similar to those heretofore mentioned. An exhalation valve is included in the fitting attached between the facepiece and rubber tube, and valves to prevent back flow are also included in the canister at the upper or outgoing side.

Carbon Monoxide Gas Masks

Canisters to restrain carbon monoxide are also made in Germany. Sometimes a half mask that covers the nose and mouth but not the eyes is used, as carbon monoxide itself does not irritate the eyes. When smokes are also present, as at fires, or irritating gases are present the full masks to protect the eyes are necessary. Men employed at fuel gas distributing lines and at blast furnaces use some of the half masks. They allow freer vision but are more difficult to fit tightly to the face than the full masks.

The writer had an opportunity to wear a carbon monoxide gas mask during a chamber test in 1 per cent of the gas and was well protected. He has not, however, examined the interior construction of the canisters for removing carbon monoxide, and no exact description is given in the published articles that have appeared.[14] The carbon monoxide canister is rather large, 8.5 by 16.5 by 24.5 cm. in size, and weighs 3 kilograms (6.6 pounds). Air enters at the bottom as it is worn, passes through two separate layers of calcium chloride or other drying material, and then through a layer of hopcalite, where the carbon monoxide is caused to unite with oxygen to form carbon dioxide. A layer of alkaline granules then removes the carbon dioxide. This is followed by a second layer of hopcalite to remove any further traces of carbon monoxide passing the first hopcalite. Then there is another layer of drying material. The last layer includes some granular calcium carbide to give warning of the exhaustion of the hopcalite by evolving acetylene when water vapor begins to penetrate the hopcalite and react with the calcium carbide. The odor of the acetylene informs the wearer of the approaching end of the usefulness of the canister, but it is stated that the canister may still be used one quarter as long as previously before dangerous quantities of carbon monoxide penetrate.

According to Bunte, the carbon monoxide canister also protects against hydrogen cyanide, ammonia, hydrogen sulphide, phosphine, arsine, sulphur dioxide, ethylene, benzene, and some other gases. Wollin states that the life of the canister in use against carbon monoxide is 15 to 30 hours. Laboratory tests against moist or dry air containing carbon monoxide have shown the life to be at least 8 hours and possibly more.[15]

Manufacture of Gas Masks in Germany

Two manufacturers are producing gas masks in Germany -- the Deutsche Gaslühlicht Auer Gesellschaft, with offices in Berlin and factory at Oranienburg; and the Drägerwerk of Lübeck.

The former firm is known widely as the manufacturer of Welsbach mantles for gas lights. Because of its work with gas mantles and the proficiency of the technical staff with gases the Deutsche Gaslühlicht Auer Gesellschaft undertook gas-mask manufacture during the World War and since then has made industrial gas masks. At present it is the only manufacturer in Germany of carbon monoxide gas masks. It makes the hopcalite for these masks. There is a chemical and physical laboratory at the plant at Oranienburg, where about 12 full-time chemists or physicists are employed on gas-mask testing, research, and development under the direction of Karl Wollin, Diplom engineer, and Dr. E. Smolczyk, chief chemist. The laboratory has developed a filter that retains very fine suspensoids, and the company is now specializing in certain canisters being marketed as fog filters.

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[14] - a Bunte, K., Eine Gasmaske zum Schutz gegen Kohlenoxyd: Gas und Wasserfach, vol. 69, 1926, pp. 815-816.
b Wollin, K., Über die Anwendung des Degea-Co-Gerätes: Gas und Wasserfach, vol. 72, 1929, 210-213.

[15] - a Von Hoff, C., Prüfung der Kohlenoxyd bindenden Degea Patrone: Glückauf, vol. 64, 1928, pp. 1414-1418.
b Heinrich, F., and Petzold, F., Prüfung einer Kohlenoxyd-Gas maske: Die Chemische Fabrik, 1928, pp. 19-22.

The Drägerwerk at Lübeck manufactures a variety of respiratory appliances, including gas masks. At present, its masks include those for all gases except carbon monoxide, but a plant for the manufacture of hopcalite is being installed and a carbon monoxide gas mask will be marketed soon. The Drägerwerk is known widely for its Dräger oxygen breathing apparatus, and it makes most of the oxygen apparatus used in Germany. The firm was the pioneer in Germany in the manufacture of such apparatus, and Dräger apparatus are used now in many parts of the world. It also makes gas appliances for physicians' use in anaesthesia and in producing sprays of medicinals for inhaling and the like, also pulmotors for resuscitating persons with oxygen administered by a mechanism to cause artificial breathing. Because of its experience with breathing apparatus, the Drägerwerk made German military gas masks and since the World War makes many industrial gas masks and respirators.

The Drägerwerk maintains a research laboratory for chemistry and physical chemistry with a personnel of five. The laboratory is directed by Dr. Gerhard Stampe, chief chemist. One feature of this laboratory that should be mentioned is a method for generating fogs for testing filters. Gas under high pressure is discharged from a fine orifice against a plate normal to the stream, all under the surface of a paraffin oil. The gas generates and carries with it a fog of the oil. The outgoing stream passes through a Regener spiral tube separator where any larger droplets are deposited. The fog then used for testing filters corresponds in quality to tobacco smoke. The percentage efficiency of the filter is read direct from the scale of an optical device with a bifurcated circular field of vision for comparing intensities of light reflected from the suspensoids before and after filtering. The optical apparatus was developed by the Drägerwerk laboratory, in colaboration with Zeiss, the well-known manufacturer of optical instruments.

Proposed Use of Carbon Monoxide Gas Masks in German Mines

Gas masks are not permitted at present in German mines. The carbon monoxide masks received consideration in past years but were not acted upon favorably. Now they are again under consideration in view of their wide and successful use in the United States. The German Government and the mining industry work together in the investigations, with final authority vested in the former.

Insurance against accidents to miners is compulsory in Germany; the employer bears all expenses. The mine operators have a national association to handle matters pertaining to accident compensation and to organize effort toward reduction of accidents. The association is subdivided into local organizations in eight districts. A central or chief mine rescue station of a district supervises and provides training for the personnel of the rescue stations at the mines within the district. The chiefs of the eight central mine rescue stations and a representative of the governmental Ministerium für Handel und Gewerbe of Berlin constitute a board that determines the safety and practicability of rescue equipment and methods and sanctions or recommends such new equipment and methods. Two of the central rescue stations, at Essen in Westphalia and at Beuthen in Silesia, are designated as testing stations. Mine rescue equipment under consideration is tested at these stations, both of which must report favorably on the results of its tests as a prerequisite to the board's recommendation.

The writer visited the testing station at Essen, the Hauptstellung für das Grubenrettungswesen. It has a laboratory for chemical and physical tests of rescue apparatus and a gallery and chamber for tests of apparatus on men. The results of the laboratory tests of carbon monoxide gas masks have been published by Von Hoff, already cited.[16] They were favorable, and it is understood that similar results were obtained in the laboratory tests at Beuthen. The tests at both stations are receiving the consideration of the board mentioned. Further tests of the masks in mines for experimental purposes are contemplated.

A schedule of tests for oxygen breathing apparatus undergoing approval has been published,[17] but no schedule of tests and specifications for gas masks is yet formulated. The gas mask, however, fails to meet the requirement for resistance to breathing as specified for the oxygen apparatus; that is, the resistance to breathing, with a fresh purifier, and an air consumption of 50 liters per minute, must not be more than about 50 mm. of water on inhalation or 75 mm. on exhalation. The test is made with an "artificial lung" on a completely assembled mask or apparatus. The carbon monoxide gas mask showed a resistance of ± 100 mm. of water, according to Von Hoff. The resistance requirement will probably be met by improved gas masks which manufacturers are attempting to produce.

One step toward the approval of the gas mask has already been completed in that the leather facepiece as used with gas masks has been applied to oxygen breathing apparatus and its use there is fully sanctioned. The facepiece permits normal breathing through the nose instead of using the mouth tube and nose clip, when it is used with the oxygen apparatus; and the facepiece arrangement is preferred in some regions, especially in Silesia.

GAS MASKS IN FRANCE

The Carteret Laboratoires of Paris, with a factory at Boulogne sur Seine, manufacture industrial gas masks, including a carbon monoxide gas mask. These masks are used above ground in many industries. The carbon monoxide mask has been used underground quite extensively by workers in long railroad tunnels but not as yet in mines. The fire departments in France also have not used gas masks. The Carteret and foreign-made carbon monoxide masks received consideration from the Comite Central des Houilleres de France at their laboratory at Montlucon, in view of their possible use in mines.[18]

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[16] - See footnote 14 a.

[17] - Richtlinien des Ausschusses für das Grubenrettungswesen in Preussen für die Zulassung von Gasschutzgeräten im Bergbau. Vom 31 Oktober 1925: Ztschr. Berg-, Hütten - und Salinwesen in preussischen Staate, vol. 73, 1925, pp. B434-439.

[18] - Delmas, L., L'emploi des appareils protecteurs contre l'oxyde de carbone dans les mines: Stages d'instruction pour ingineurs: Comite Central des Houilleres de France, Note Technique 85, 1928, pp. 131-150.

Description of Carteret Gas Masks

The Carteret gas masks are made in two forms, one with a small drum canister attached direct to the facepiece and the other with larger canisters, which are supported on the wearer's body and connect to the facepieces through flexible rubber tubes. The facepieces are made in both full masks of the Tissot type (for nose breathing), and half masks that leave the eyes uncovered. Both masks are fabricated of rubberized cloth; the rubber and cloth are rather light, but a number of layers are superimposed with adhesive to give body to the masks. The eyepieces are of celluloid. The full-face mask has a metal connecting tube between the facepiece and the corrugated rubber tube from the canister. This metal tube includes an inhalation valve, metal disk type, to prevent backflow of exhalations; and there is a rubber flutter valve for exhaling.

The carbon monoxide gas mask has two cylindrical canisters[19] joined by a tube below. The canisters are carried in the pockets of apron supports on the wearers. Inspired air enters one canister through an opening at the top, passes downward through a reactive mixture of iodine pentoxide and sulphuric acid on pumice granules (proportions are pumice 1 liter; concentrated H_2SO_4 60 c.c.; I_2O_5 120 g.) where any carbon monoxide is oxidized to carbon dioxide. Iodine passes with the air to the second canister and is removed there by an absorbent of granular charcoal, an alkaline granule, or mixtures of these. The apparatus also restrains various other irrespirable gases.

When the mask is not in use the two canisters are separated and closed on both ends with screw caps to preserve the contents from deterioration by moisture in the air.

Life of Carbon Monoxide Gas Masks

The ordinary size of the two canisters is 500 c.c. each; these may, according to Tassilly, serve 90 minutes for protection in an atmosphere containing not more than 1 per cent of carbon monoxide when the wearer does only light work. For higher concentrations or active work, larger canisters of 750 c.c. or 1000 c.c. are advised.

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19 - a Guillemard, H., Respiratory Device: U. S. Patent 1508970, Sept. 16, 1924. Process for purification of air rendered impure by carbon monoxide or other deleterious gas and intended for respirations: U. S. Patent 1611524, Dec. 21, 1926.

b Desgrez, A. (?)., Guillemard, H., and Hemmerdinger, A. (?), Sur la protection individuelle contre l'oxyde de carbone; reactif et appareil: Compt. rend, vol. 173, 1921, pp. 616-618.

c Tassilly, E., Techniques nouvelles concernant la detection de l'oxyde de carbone dans l'atmosphere et la protection contre ce gaz: Bul. Sci Pharmacolog, vol. 30, 1923, pp. 513-524.

d Guillemard, H., and Lihrmann, A., Sur l'emploi du reactif iodicosulfurique pour la protection contre l'oxyde de carbone et autres gaz toxiques: chim. et Ind., vol. 14, 1925, pp. 29-32.

Early tests of the ordinary-size canisters at Montlucon under the Comité Central des Houilleres de France showed that they were able to purify about 700 liters of air containing 1 per cent of carbon monoxide. This corresponds to a life of about 45 minutes for a man doing light work, according to Delmas. Since these tests were made the canisters were apparently improved. When the carbon monoxide is less than 1 per cent the life of the canister is correspondingly longer. Water vapor from the air, however, is absorbed by the sulphuric-iodic acid which, on this account, gradually loses its ability to oxidize carbon monoxide, even though no oxidizing action has occurred.

GAS MASKS IN BELGIUM

When the writer visited Belgium no industrial gas masks were being manufactured there. The industries and fire departments were, however, using some masks imported from other countries.

Carbon monoxide gas masks and self-rescuers for use in mines had been investigated and some tests thereof had been made at the Institute National des Mines à Frameries.

One manufacturer, Establissements Jules Fonson, of Brussels, is developing some industrial gas masks. The firm now manufactures saddlery and military accessories but heretofore has made parts of gas masks for military purposes. It expects to have some complete masks under production that will be adapted to Belgian industry above ground.